Space Weather Technical Forecast

Issued on Friday, 03 November 2023 at 13:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Further M-class flares likely throughout. G1/G2 Minor/Moderate geomagnetic storms likely day 3 (05 Nov).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate with a peak flare of M1.6 at 02/1222 UTC from AR3474, with also a M1.0 flare at 02/1921 from an unnumbered region in the southeast. AR3474 is the large and complex spot in the southwestern quadrant, with its trailing region still having a contender for a delta spot. AR3477 in the southeast was responsible for an impulsive M1.6 flare at 02/1222 UTC, this has a very large umbra and penumbra in it's leading portion with only a small trailing region. The new spot that has rotated around the southeast limb also appears to be magnetically complex and large, perhaps with a delta region in the centre portion of the disk, though due to foreshortening, this is yet to be verified. All other regions are small and simple.

A large filament eruption was detected around 03/0430 UTC from the northwest quadrant. This has yet to be modelled completely but initial expectations are for an Earth-directed CME to arrive later on 05 Nov.

Solar Wind / Geomagnetic Activity: Solar wind speeds observed at L1 by ACE are background, around 350 km/s. Density has persisted at below average values. The total magnetic field strength, Bt, has been persistently weak, with the north-south component, Bz, also varying weakly. Phi angle was predominantly positive (away from the Sun). Geomagnetic activity was Quiet (Kp 0-2) throughout.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux was at background levels, though slightly above baseline following the filament lift off from the northeast quadrant. GOES16 high energy (greater than 2MeV) electron flux was at High levels between 02/0925-2225 UTC, then again from 03/1015 UTC onward, with a peak of 2380 pfu at 02/1525 UTC. The associated 24-hour fluence has been above the Active (1e8 integrated pfu) threshold throughout. The observation for integrated pfu at 03/0000 was 1.11e8.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate solar activity is expected, with further isolated M-class flares likely.

Solar Wind / Geomagnetic Activity: Two CME's feature in the forecast, one from 31/2200 UTC which may arrive late 04 or early 05 Nov, and another from 03/0430 UTC which is expected to arrive later on 05 Nov.

Solar wind speeds are slow. The next enhancements will be from CME's from late day 2 (04 Nov) with speeds of 500-700 km/s, followed by CH67/-, which may enhance solar wind speeds to strong, around 600-700 km/s from later on day 4 (06 Nov).

Quiet geomagnetic activity initially with a chance of isolated Unsettled intervals. Unsettled to Active levels and a slight chance of G1/Minor Storms are possible during the latter part of day 2 (04 Nov) or more likely early day 3 (05 Nov) due to the glancing CME from 31 Oct. Later day 3

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

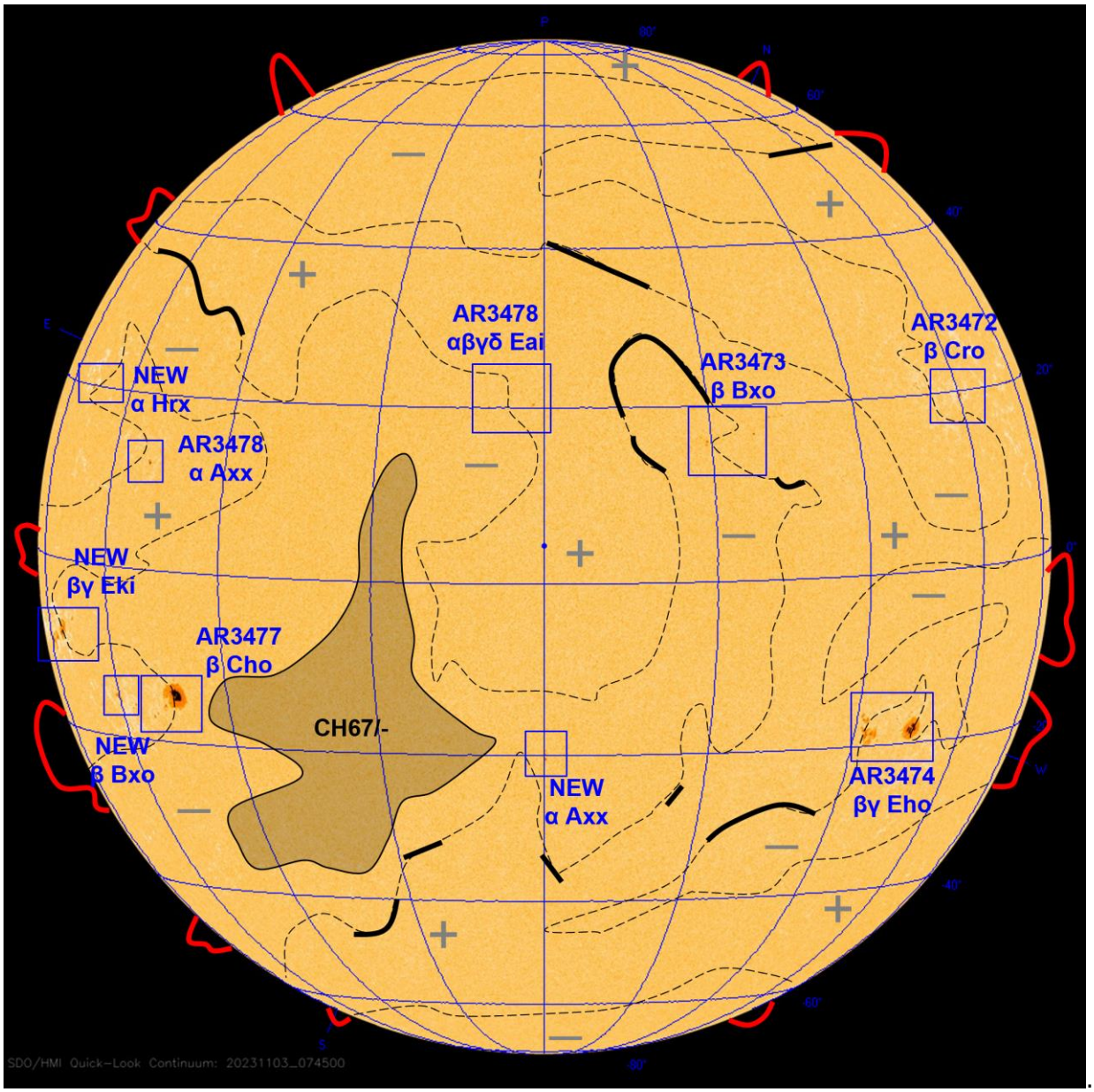
(05 Nov), G1/G2 Minor/Moderate storms will become likely with a slight chance of G3/Strong storms due to the arrival of the large filament eruption associated CME from 03 Nov. Day 4 (06 Nov) will likely see geomagnetic activity ease before the risk once again increases later due to the potential early arrival of the HSS from CH67/-.

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is expected to persist at background levels, with a daily slight chance of minor solar storms due to filament eruptions or flares from either of two sunspots on the disk. High energy electron flux (greater than 2MeV) is forecast to oscillate between mainly Moderate and High levels today and tomorrow, but with a decreasing day-on-day peak, then ending the period at background to moderate levels. Electron fluence values are now just above the Active (greater than 1e8 integrated pfu) threshold and is expected to remain above this level today (03 Nov), with a declining trend thereafter.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 1. Solar Analysis Valid 03/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Met Office Space Weather Technical Forecast

Geomagnetic Storms:

A filament eruption from the southeast disc around 31/2200 UTC resulted in a CME that may give Earth a glancing blow either late tomorrow (04 Nov) or early day 3 (05 Nov). A second filament eruption was detected around 02/0230 UTC from a region close to AR3479 in the northeast, but has been modelled as missing Earth. A large filament eruption was observed in the northwest of the disk on 03/0430 UTC, this is awaiting final computation, but initial estimates are for this CME to arrive at Earth from midday on 5th Nov +/- 6 hrs.

Solar wind speeds are slow. Coronal hole 67/-, currently just east of the meridian, may provide an enhancement from late day 4 (06 Nov) onward. This coronal hole is larger and darker than previous rotations so may bring faster speeds and a earlier onset of the high speed stream, though on the previous rotation, Earth did not seemingly connect to the southern portion, therefore connection this time around may be beyond the current forecast period. Solar wind speeds of 600-700 km/s could be realised when connecting to this CH HSS.

Mainly Quiet geomagnetic activity is expected with a chance of isolated Unsettled intervals. Unsettled to Active levels and a slight chance of G1/Minor Storms are possible during the latter part of day 2 (04 Nov) or more likely early day 3 (05 Nov) due to the glancing CME from 31 Oct. Later day 3 (05 Nov), G1/G2 Minor/Moderate storms will become likely with a slight chance of G3/Strong storms due to the arrival of the large filament eruption associated CME from 03 Nov. Day 4 (06 Nov) will likely see geomagnetic activity ease before the risk once again increases later due to the potential early arrival of the HSS from CH67/-.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	20	70	20
Strong	G3	No	1	1	15	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

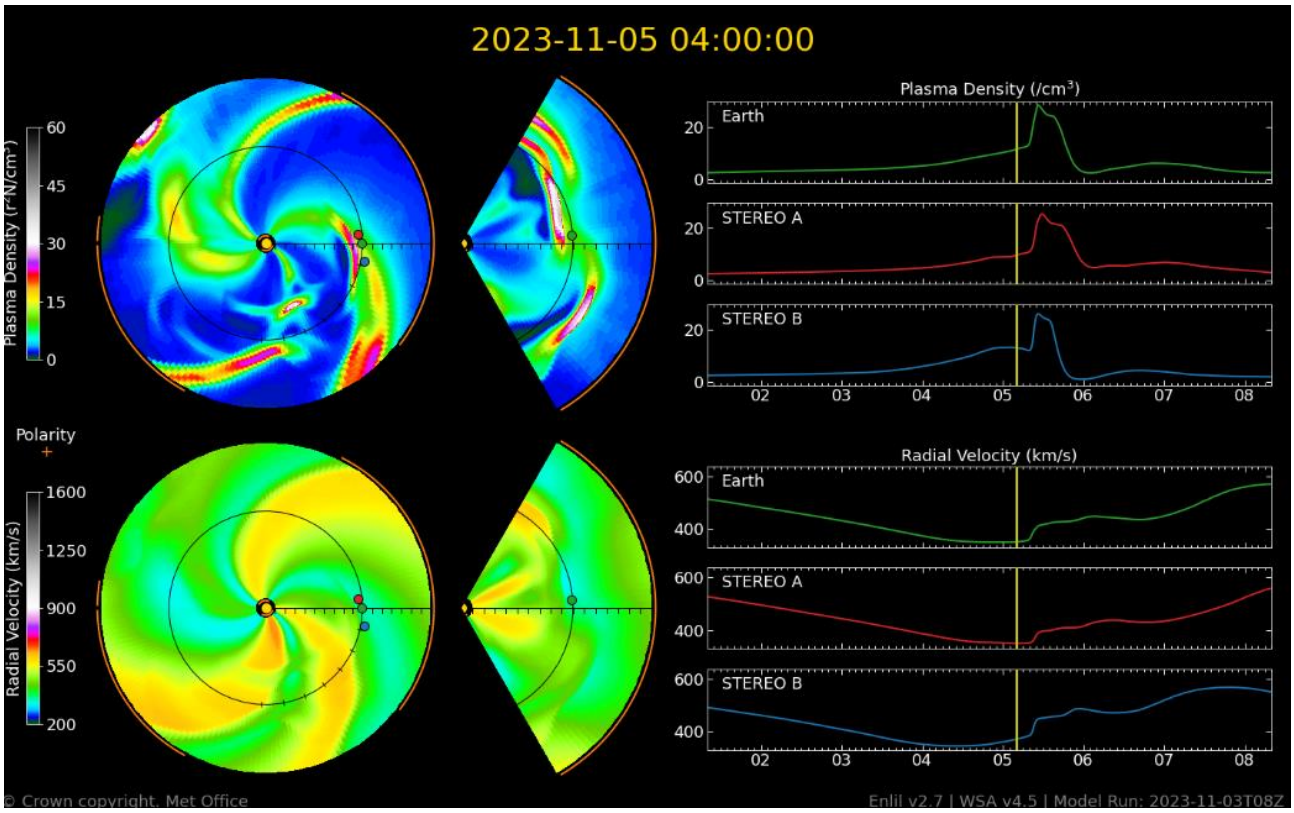
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
01/0412	Partial	Filament eruption	SE	550 km/s	05/0000	Glancing blow
03/0430	Partial	Fialment Eruto[pm	NW	730 km/s	05/1200 +/- 6 hrs	G1/G2 likley.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 2: ENLIL showing arrival of first CME



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

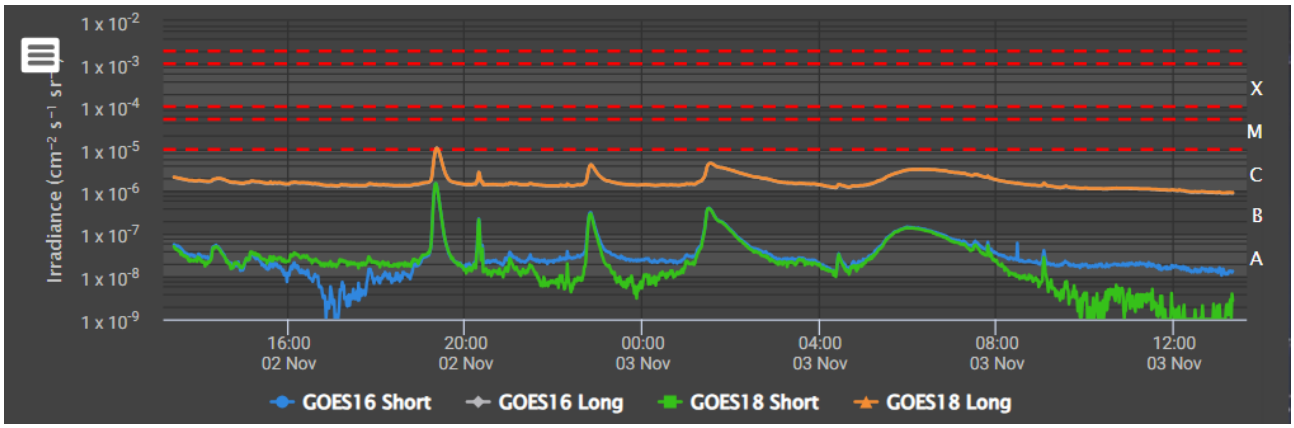
Radio Blackouts - X-Ray Flares:

There are six numbered sunspots on the visible disc. There are two large numbered and another large unnumbered spot. AR3474 is the large and complex spot in the southwestern quadrant, with its trailing region still having a contender for a delta spot. AR3474 in the southeast was responsible for an impulsive M1.6 flare at 02/1222 UTC, this has a very large umbra and penumbra in it's leading portion with only a small trailing region. The new spot that has rotated around the southeast limb also appears to be magnetically complex and large, perhaps with a delta region in the centre portion of the disk, though due to foreshortening, this is yet to be verified. All other regions are smal and simple.

Solar activity has been Moderate with two M-class flares in the past 24 hours. The peak flare being an M1.6 at 02/1222 UTC from AR3474, followed by a smaller M1.0 flare from the new region on the southeast limb at 02/1922. Low to Moderate activity is expected to continue with further isolated M-class flares likely, these most likely from AR3477, AR3474 or the new region on the southeast limb.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	50	50	50
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: 24 hour Xray trace



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

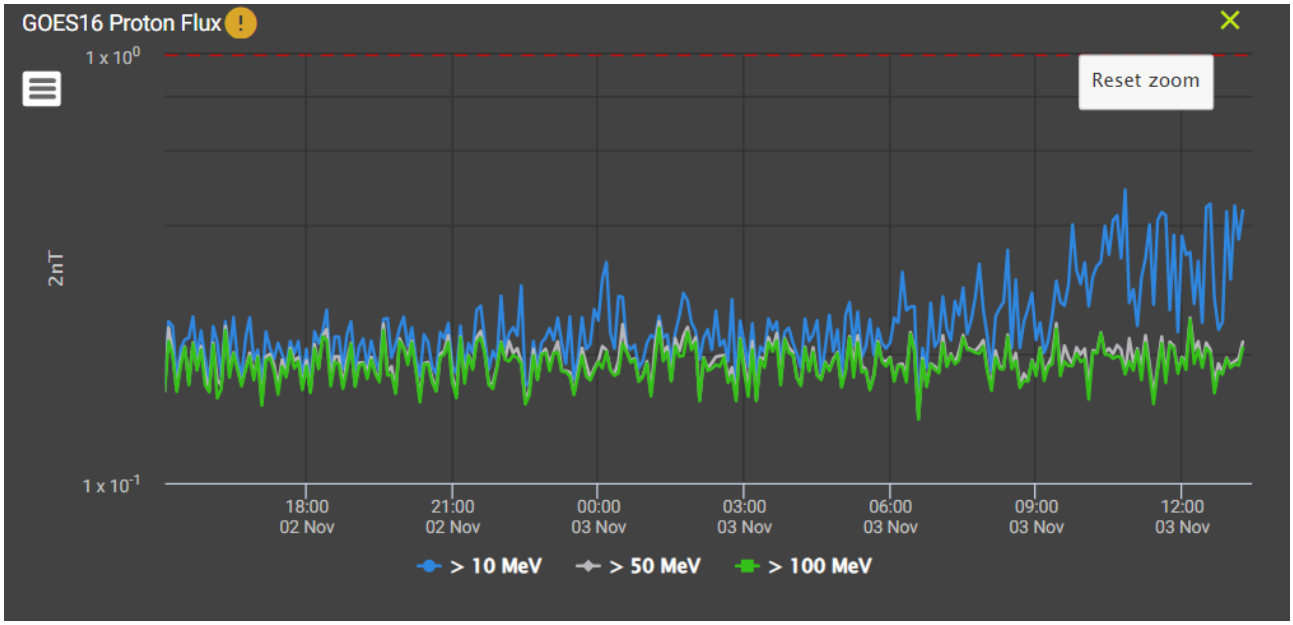
© Crown Copyright 2023. All Rights Reserved.

Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is expected to persist at background levels, although there is a very slight chance of proton storms from AR3474 as it is currently in a favourable location, in the western hemisphere of the visible disc, or from the new and complex region in the southeast of the disk.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: 24 hour proton trace



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

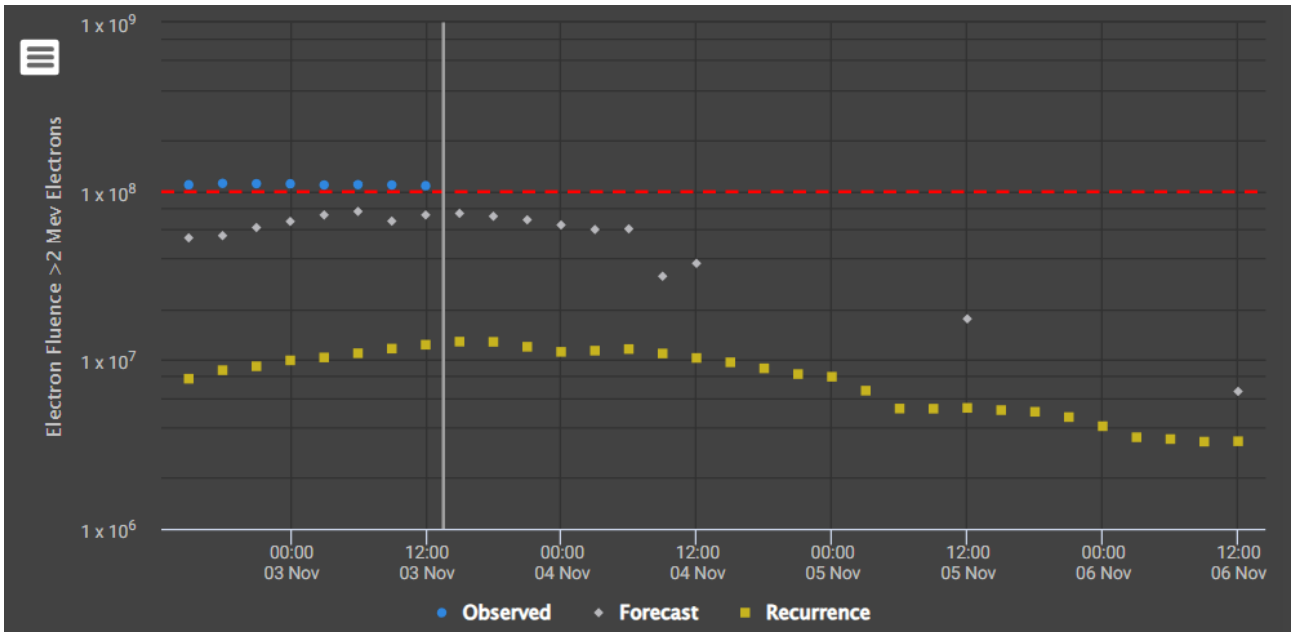
High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) is expected to continue to vary between Moderate and High levels initially. A gradual day-on-day decrease in diurnal maxima is probable during the period, as the influence of the previous HSS from CH66 declines, with more persistently background or Moderate levels likely for days 3 and 4 (5th and 6th).

Electron fluence has exceeded the Active (greater than 1e8 integrated pfu) threshold and is expected to remain above this level today (03 Nov), with a declining trend from tomorrow onwards. The MOSWOC REFM model is therefore considered to be offering good guidance regarding the trend of the fluence, although the model is currently underestimating the fluence and has us below the 1e8 integrated pfu threshold.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	100	80	30	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: REFM



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.